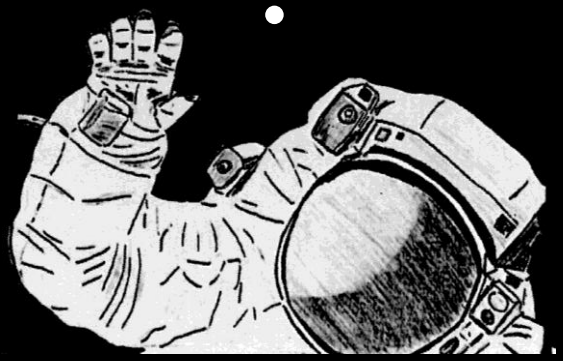
SMALL SPACECRAFT TECHNOLOGY PROGRAM

NASA SPACE TECHNOLOGY MISSION DIRECTORATE



AUGUST 2013

ANDREW PETRO, PROGRAM EXECUTIVE
BRUCE YOST, PROGRAM MANAGER

NASA SSTP @ Small Sat Conference

STMD/Small Spacecraft Technology Exhibit and the NASA Ames exhibit

- Schedule time to talk with Andy and Bruce

Keynote by STMD Associate Administrator, Mike Gazarik

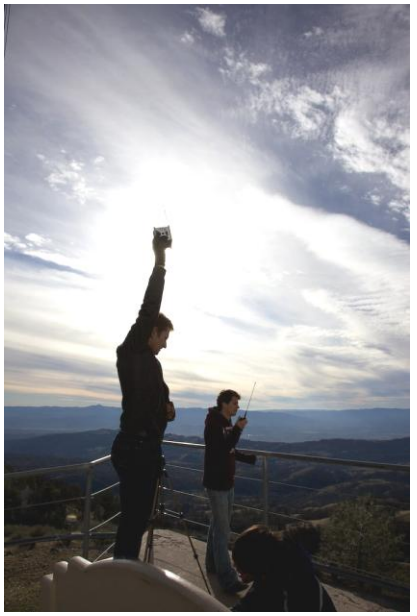
See more online at www.nasa.gov/smallsats

SMALLSAT TECHNOLOGY PARTNERSHIPS

Cooperative agreements with US colleges and universities to develop and/or demonstrate new technologies and capabilities for small spacecraft in collaboration with NASA.

One to two year projects
Up to $100,000 per year, per university (up to $150,000 if more than one university)
Up to 1.0 FTE in NASA labor per year, per project

13 Projects selected on August 8, 2013
17 different universities and colleges
6 NASA Center partners



SMALLSAT TECHNOLOGY PARTNERSHIPS
2013 AWARDS

COMMUNICATIONS

High Rate Cubesat X-band/S-band Communication System
PI: Scott Palo
University Of Colorado
NASA Partner: Goddard Space Flight Center

Space Optical Communications Using Laser Beam Amplification
PI: Govind Agrawal
University Of Rochester
NASA Partner: Ames Research Center

Development of Novel Integrated Antennas for Cubesats
PI: David Jackson
University Of Houston
NASA Partner: Johnson Space Center

SMALLSAT TECHNOLOGY PARTNERSHIPS
2013 AWARDS

GUIDANCE, NAVIGATION & CONTROL

Smallsat Precision Navigation With Low-Cost MEMS IMU Swarms
PI: John Christian
West Virginia University
Partner: Marquette University
NASA Partner: Johnson Space Center

Cubesat Autonomous Rendezvous & Docking Software
PI: Glenn Lightsey
University Of Texas
NASA Partner: Johnson Space Center

Radiation Tolerant, FPGA-based Smallsat Computer System
PI: Brock LaMeres
Montana State University
NASA Partner: Goddard Space Flight Center

An Integrated Precision Attitude Determination and Control System
PI: Norman FitzCoy
University Of Florida
NASA Partner: Langley Research Center

SMALLSAT TECHNOLOGY PARTNERSHIPS
2013 AWARDS

PROPULSION

Propulsion System and Orbit Maneuver Integration in Cubesats
PI: Jennifer Hudson
Western Michigan University
NASA Partner: Jet Propulsion Lab

Film-Evaporation MEMS Tunable Array for Picosat Propulsion and Thermal Control
PI: Alina Alexeenko
Purdue University
NASA Partner: Goddard Space Flight Center

POWER

Smallsat Low Mass, Extreme Low Temperature Energy Storage
PI: Sharlene Katz
California State University - Northridge
NASA Partner: Jet Propulsion Lab

SMALLSAT TECHNOLOGY PARTNERSHIPS
2013 AWARDS

SCIENCE INSTRUMENT CAPABILITIES

Compressive Sensing for Advanced Imaging and Navigation
PI: Richard Kurwitz
Texas A&M University
NASA Partner: Langley Research Center

Mini Fourier-Transform Spectrometer for Cubesat-Based Remote Sensing
PI: John Allen
Appalachian State University
Partner: University of Maryland - Baltimore County
NASA Partner: Goddard Space Flight Center

ADVANCED MANUFACTURING

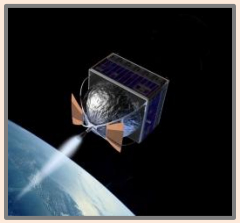
Printing the Complete Cubesat
PI: Craig Kief
University Of New Mexico
Partners: University of Texas - El Paso and Drake State Technical College
NASA Partner: Glenn Research Center

SPACE TECHNOLOGY MISSION DIRECTORATE

NINE PROGRAMS

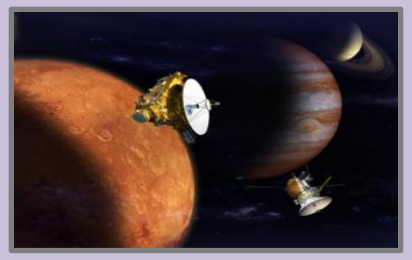
Game Changing Development

Technology Demonstration Missions

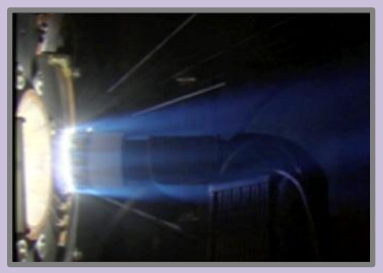


Small Spacecraft Technology

Space Technology Research Grants



NASA Innovative Advanced Concepts (NIAC)



Center Innovation Fund

Centennial Challenges

Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR)

Flight Opportunities

STMD Involvement in Small Spacecraft

· **Small Spacecraft Technology**
(Combination of former Franklin and Edison Programs)
- 2 directed flight projects: PhoneSat and EDSN (FY12-14)
- 3 flight projects from FY12 BAA (FY13-15)
- Smallsat Technology Partnerships – FY13 pilot ($1.5M + 10 FTE)
- FY13 NRA in partnership with Flight Opportunities
  - Propulsion Systems & Small Earth Return Vehicles (~$1M)

· **Game Changing Development**
- General cross-cutting technology development
- FY13 NRA for Miniaturized Electrospray Propulsion (~$5M)

· **SBIR/STTR**
- Existing subtopics for small spacecraft technology

· **Flight Opportunities**
- Technology payload development and test opportunities (FY13 NRA, etc.)

· **Centennial Challenges**
- Several relevant prize competitions in formulation

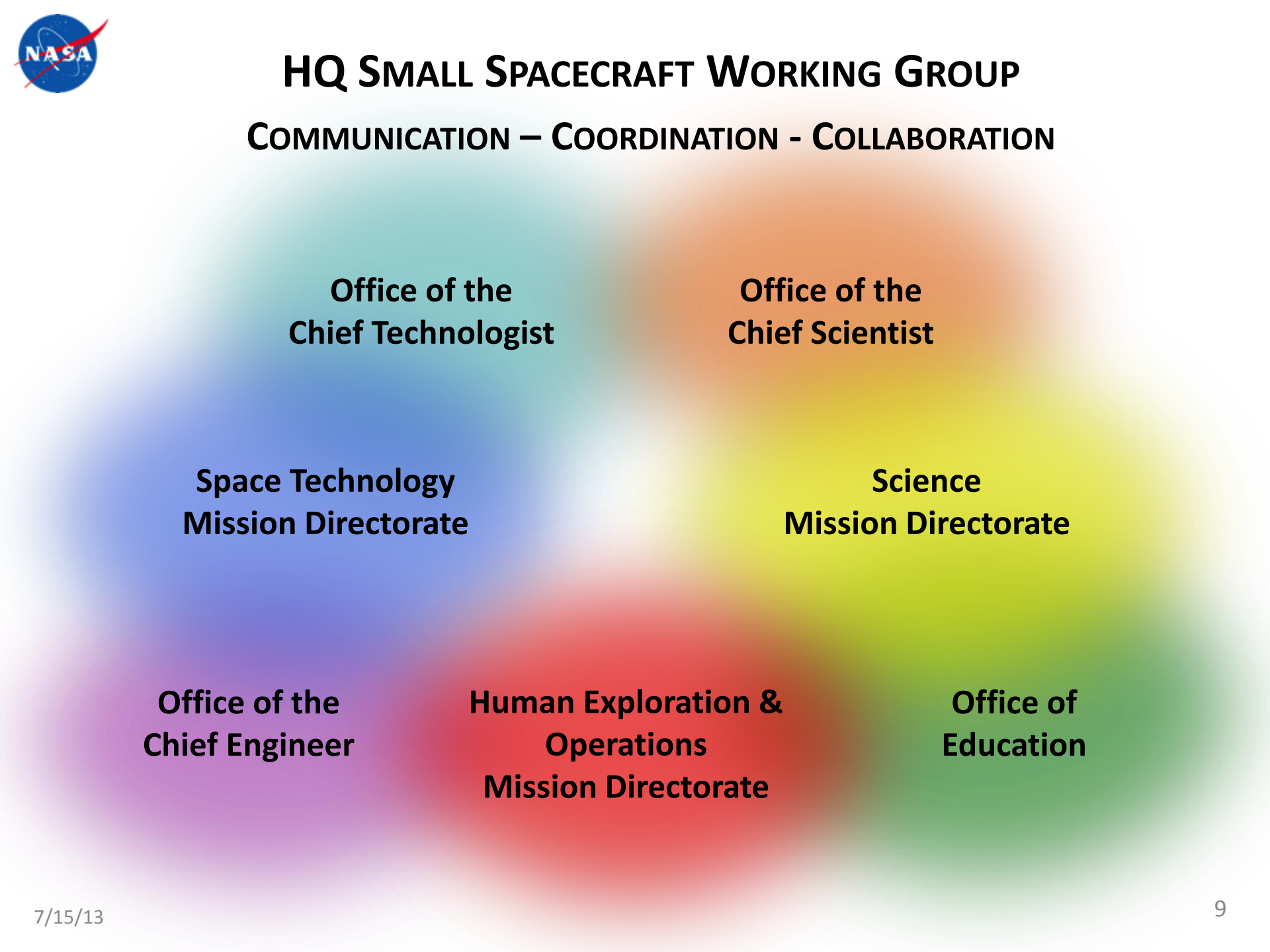
· **NIAC**
· **Space Technology Research Grants**
· **Center Innovation Fund**

} General cross-cutting concept & technology development and some small spacecraft projects

STMD also supports the **Cubesat Launch Initiative** in HEOMD and the **HOPE** Program with SMD and OCE

HQ Small Spacecraft Working Group

Communication – Coordination - Collaboration



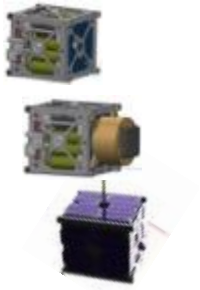
Small Spacecraft Technology Program Objectives

Advance the capabilities of small spacecraft to support NASA missions in science, exploration and space operations

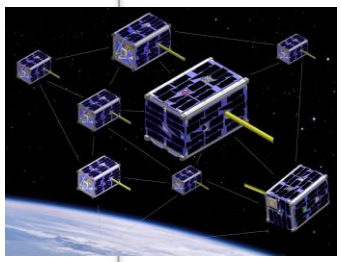
- to accelerate the introduction of new technologies and capabilities
- to perform missions or examine phenomena not possible otherwise
- to unleash NASA's unique capabilities and assets into the already vibrant small spacecraft community

SST PROJECTS - 2012

2013	2014	2015

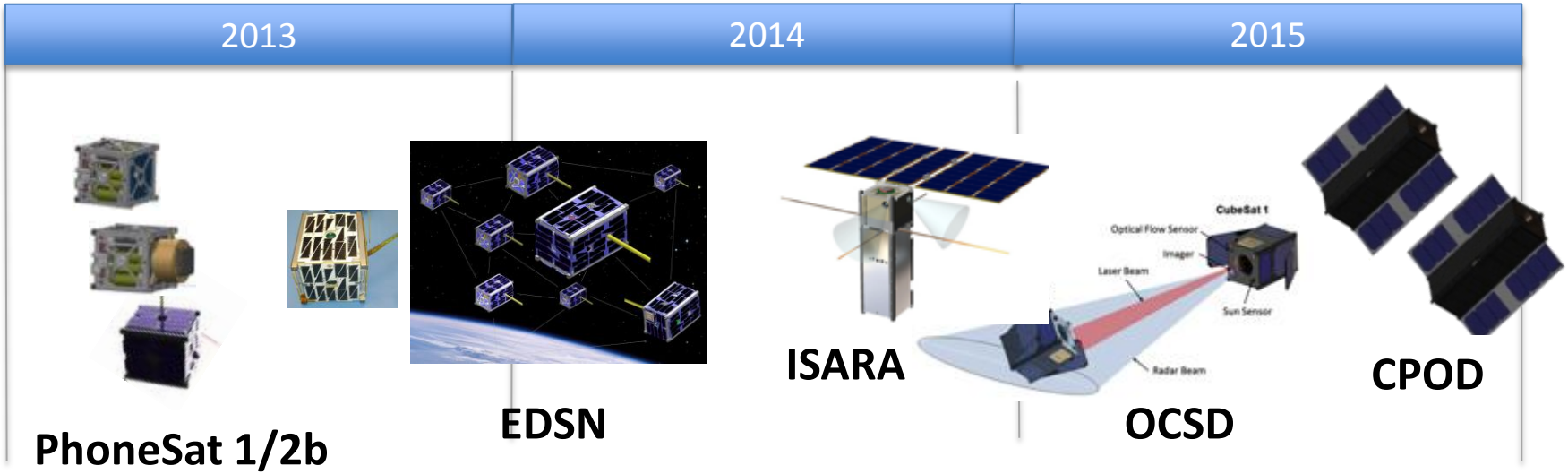


PhoneSat 1/2b

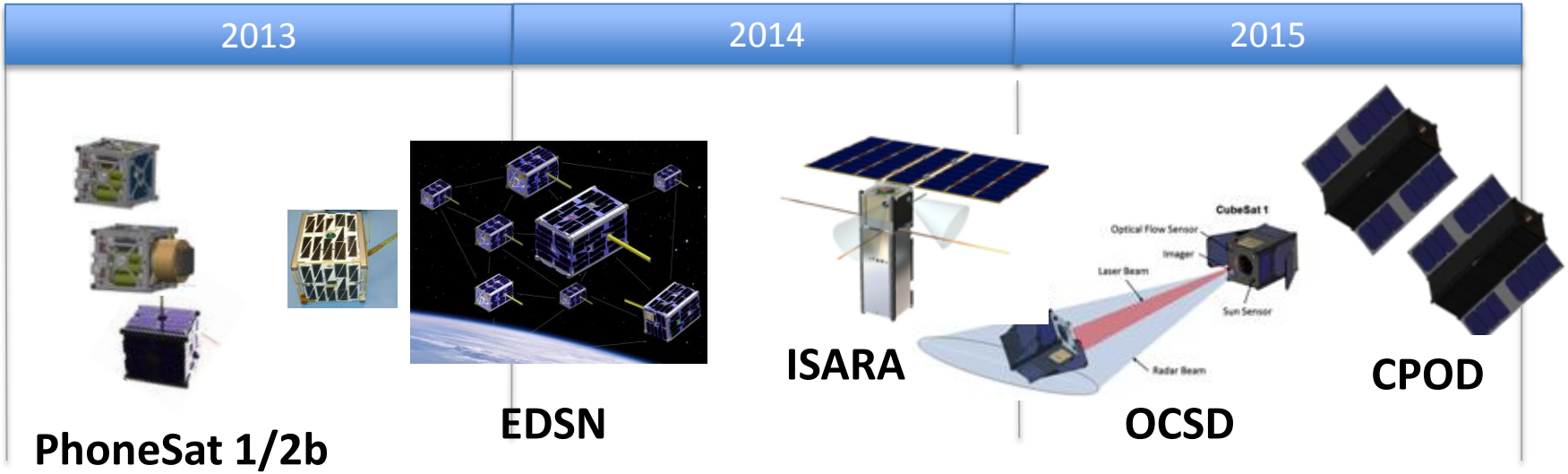


EDSN

SST PROJECTS - 2013

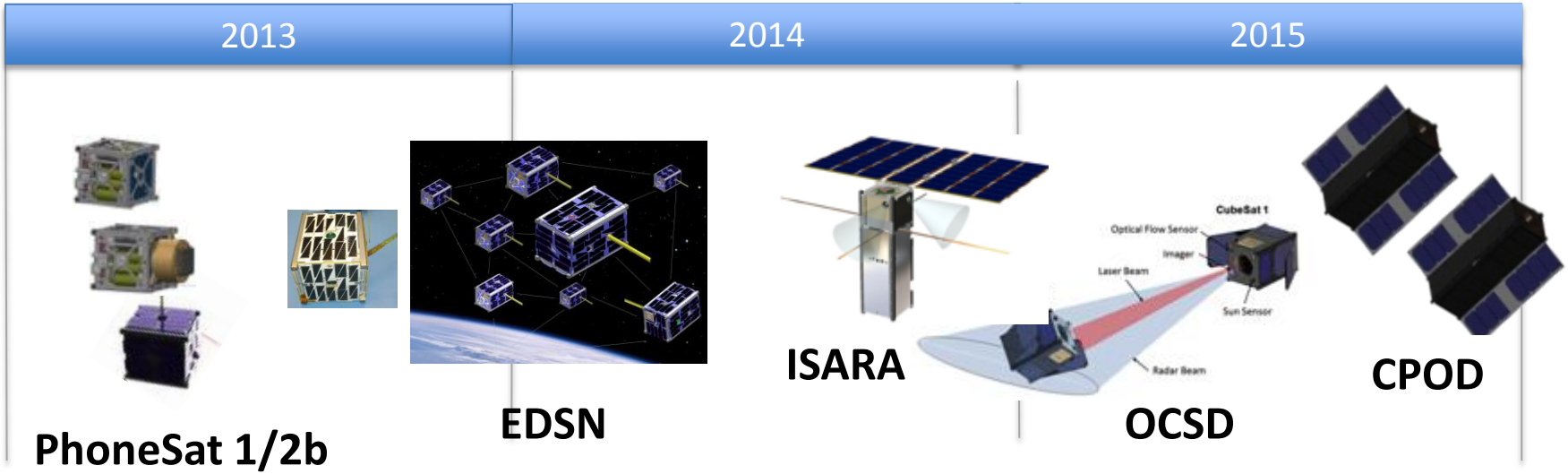


SST Projects - 2013 and Beyond



Smallsat Technology Partnerships
13 New Projects

SST Projects - 2013 and Beyond

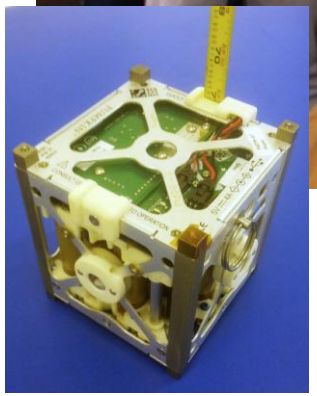


Smallsat Technology Partnerships
13 New Projects

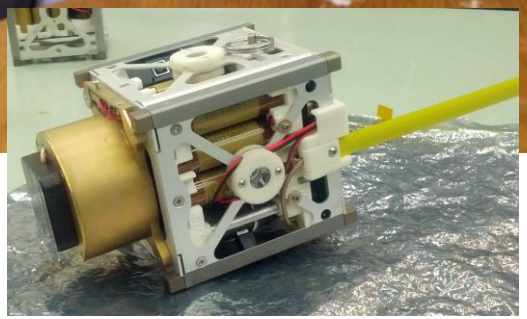
Small Spacecraft
Propulsion Projects
(Flight Opportunities NRA)

Successful PhoneSat Mission – April 21 – 26, 2013

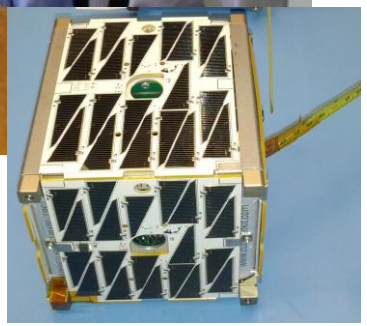
PhoneSat Team – NASA Ames Research Center



"Graham"
PhoneSat 1.0



"Bell"
PhoneSat 1.0
with Iridium experiment



"Alexander"
PhoneSat 2.0b

SMALL SPACECRAFT TECHNOLOGY - STRATEGIC ELEMENTS

ACTUAL ANNUAL ACTIVITIES WILL VARY BASED ON FUNDING AND OTHER CONSIDERATIONS

PARTICIPANTS

Focused Technology Development and Demonstration - technology concept development (TRL 3 to 5) with selective transitions to flight demonstrations (TRL 5 to 7), full and open solicitations.

NASA
Other Govt
Lg Business
Sm Business
Academia

Mission Capability Demonstrations - directed formulation phase followed by RFP for mission implementation: Industry/academia-led, NASA-led, or combination

NASA
Other Govt
Lg Business
Sm Business
Academia

Leveraged Investments - funding for SBIR Phase 2E or Phase 3 projects, CIF follow-on projects, Prize Challenges, and other initiatives – linked to technology focus areas.

Sm Business
NASA
Others

Smallsat Technology Partnerships (STP) - University-NASA partnerships for technology development and/or demonstration. 1-2 year durations.

Academia
NASA
Others

SMALL SPACECRAFT TECHNOLOGY - STRATEGIC ELEMENTS

Focused Technology Development and Demonstrations

Communications (ISARA, OCSD)	FY12-13-14
Propulsion	FY13-14-15
TBD	FY14-15-16

Future focus areas: Power Generation, Thermal, GN&C, Entry Systems, Radiation Tolerance, Flight Software

Mission Capability Demonstrations (MCD)

Constellations (EDSN)	FY12-13-14
Proximity Operations (CPOD, OCSD)	FY13-14-15
TBD	FY14-15-16

Potential future MCD's: Constellations with Propulsion, Deep space operations

Leveraged Investments - funding for SBIR Phase 2E or Phase 3 projects, CIF follow-on projects, Prize Challenges, and other initiatives linked to technology focus areas.

Smallsat Technology Partnerships (STP) - University-NASA partnerships for technology development and/or demonstration. Broad topics.

LEGEND: Black – funded efforts Blue – potential activities, pending funding

SSTP Portfolio Technology Matrix

"C3PO"

SSTP Projects	EDSN	CPOD	ISARA	OCSD	Phonesat 2.X	Comment
Comm Up-link Down-link Cross-link	□		□	□		
Propulsion		□		□		Multiple new projects
Pointing (ADCS/GNC)	□	□	□	□	□	
Power (EPS)						Future topic?
Operations (autonomy)		*Limited*				Future topic?
Structures/deployables		*Limited*	□	*Limited*		
Science architectures	□					Future topic?
Swarms/Constellations	□					
C&DH (processors)					□	

Other?

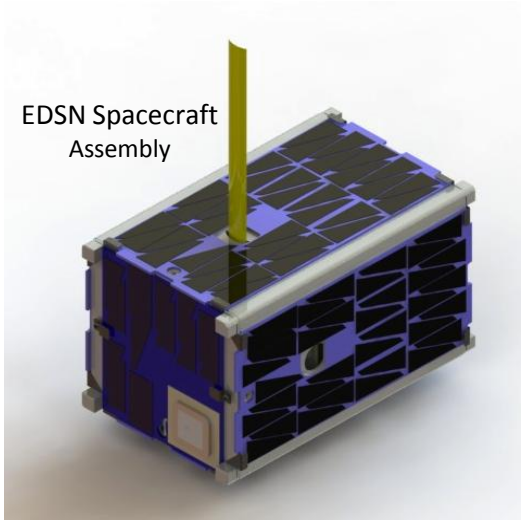
Edison Demonstration of SmallSat Networks (EDSN) Project

Project Summary

- **HQ Directorate:** Space Technology Mission Directorate
- **Governing PMC:** NASA Class D Category III Project
- **Project Manager:** Deborah Westley
- **Performing Organization(s):** ARC, MSFC
- **Partners:**
  - Montana State University – Payload provider
  - Santa Clara University – Ground Station operator

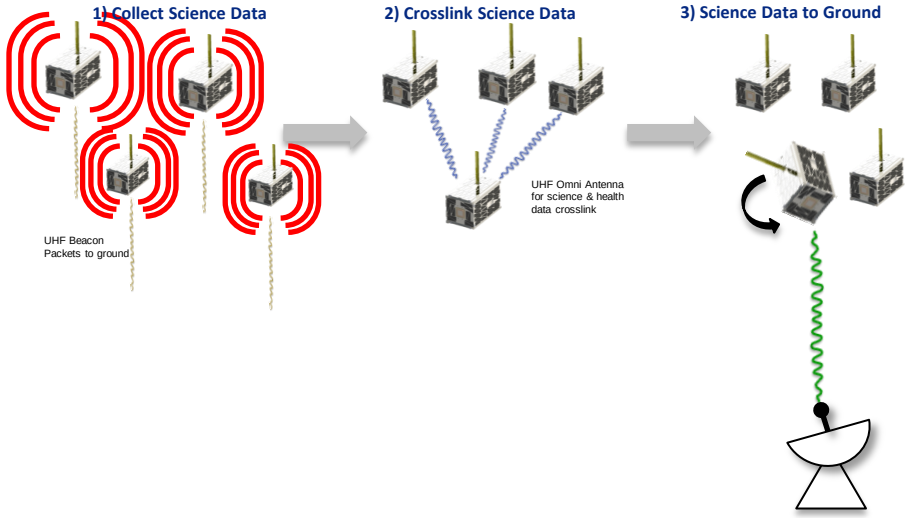
- **Description:** The EDSN Mission will launch a swarm of 8 low-cost small satellites and demonstrate the operation of an intra-swarm communication link and multi-point sensing measurements.

Description



Montana State University
EPISEM Payload

ConOps



Schedule (CY)

	2012	2013	2014

ATP △

PDR △

CDR △

FRR △

ORS Launch △ △

Mission Ops

Launch

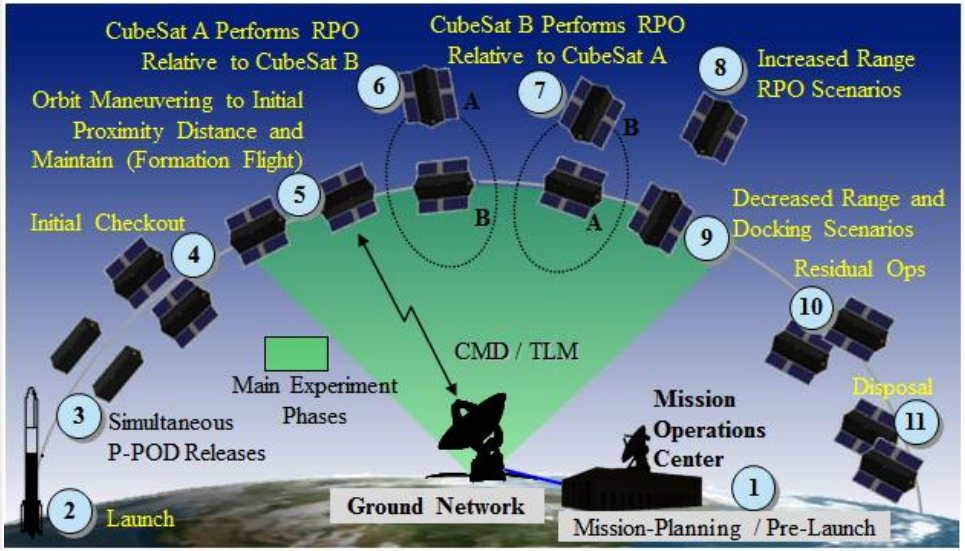
ORS Super Strypi (ORS-4)
Launched from PMRF

Proximity Operations Nano-Satellite Flight Demonstration

Project Summary

Contractor: Tyvak Nano-Satellite Systems LLC
PI: Scott MacGillivray/Tyvak
Subcontractors:
- 406 Aerospace
- Applied Defense Solutions
- Analytical Graphics Inc.
- California Polytechnic State University, San Luis Obispo

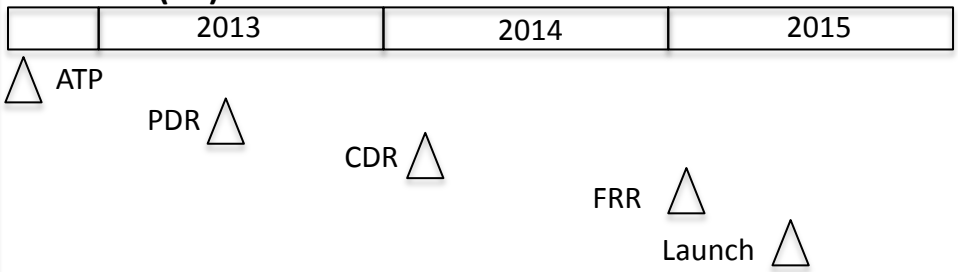
Description/ConOps



Concept of Operations

- Two 3U CubeSats will demonstrate rendezvous, proximity operations, docking and servicing, and formation flight over a 1-year nominal mission.

Schedule (CY)



Launch

- Launch is planned for second quarter of CY2015 (selected by CSLI).
- Orbit inclination > 30° for ground coverage considerations and altitude should nominally support 1 year of on-orbit operations.

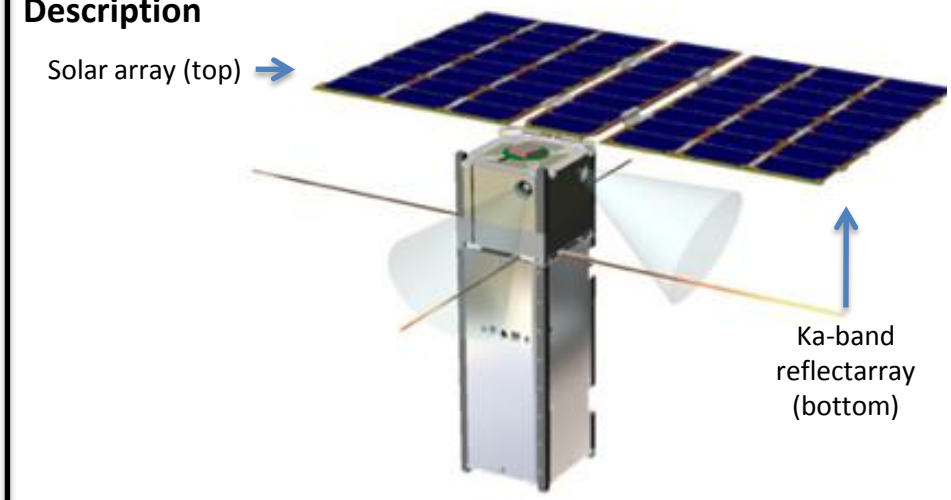
ISARA –Integrated Solar Array and Reflectarray Antenna for High Bandwidth CubeSat

Project Summary

Center: Jet Propulsion Laboratory
PI: Richard Hodges
PM: Biren Shah
Subcontractors:
- Pumpkin, Inc. (spacecraft bus)

Objective:
- Demonstrate a high bandwidth Ka-band data downlink system for cubesats

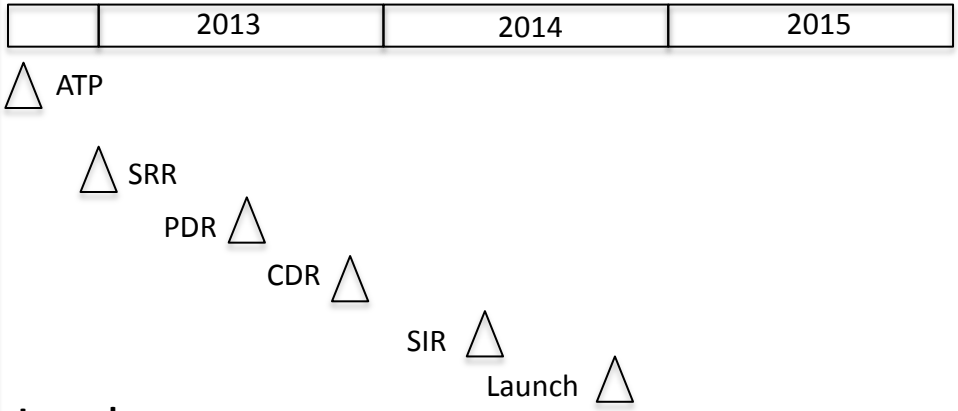
Description



Concept of Operations

- One 3U cubesat employs a large, deployable solar array that doubles as a Ka-band reflectenna providing up to 100 Mps of data downlink capability.

Schedule (CY)



Launch

- Launch planned for CY2014 (selected by CSLI)
- LEO from 300km to 700km at 51.7° is acceptable.
- GTO orbit would also be considered.

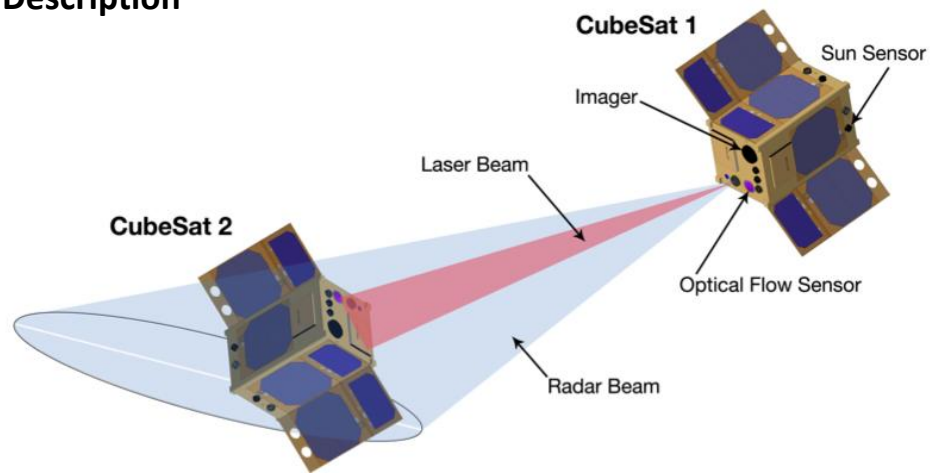
Integrated Optical Communications and Proximity Sensors Demonstration (OCSD)

Summary

Contractor: Aerospace Corp.
PI: Siegfried Janson
Subcontractors:
- N/A

Objective:
- Demonstrate radar ranging, optical downlink, cold gas propulsion, and cross-track motion sensing technologies on a cubesat proximity operations mission.

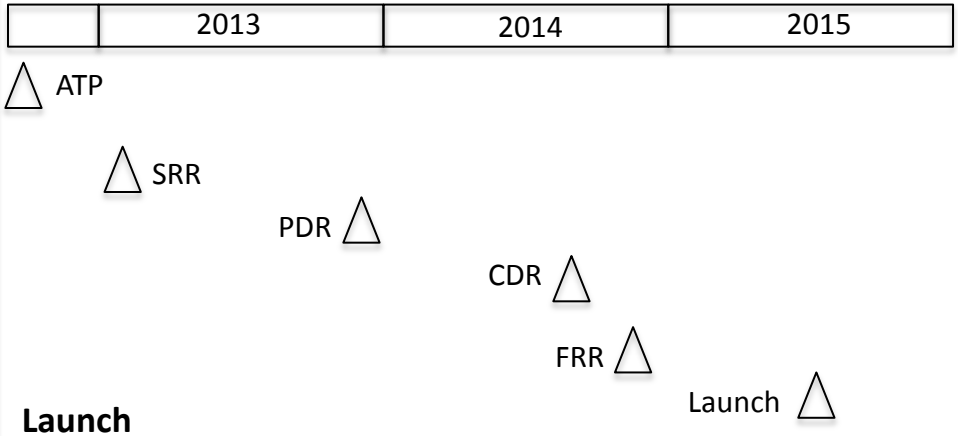
Description



Concept of Operations

- Two 1.5U cubesats execute formation flying and rendezvous operations using radar, optical flow sensor and cold gas propulsion.
- Demonstrate laser-comm downlink.

Schedule (CY)



Launch

- Launch is planned for mid CY2015 (selected by CLSI)
- LEO at 500km is sufficient.

State of the Art Analysis

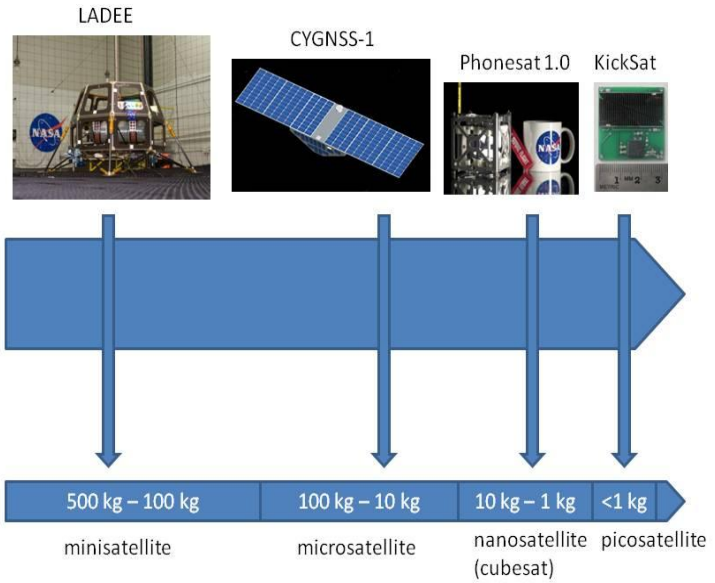
Context

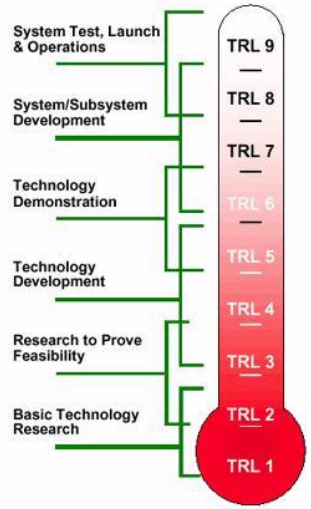
- NASA ARC has been tasked by SSTP to draft a White Paper on the State-of-the-Art (SoA) of Small Spacecraft Technology.
- Objective: Identify technology gaps for possible future strategic investment.
- Time frame: June-September 2013.
- Data collection methodology
  - Desk research
  - Outreach to Small Satellite community
    - Industry: RFI released in early August
    - Institutional stakeholders: NASA ARC, release of internal call to other NASA centers, etc
    - Academia: peer-to-peer networking, today's dialogue at SSC 2013

State of the Art Analysis

Scope

- NASA SSTP: 'small' spacecraft is a spacecraft with mass < 180 kg.
- Technology Domains
  - Power; Propulsion; ADCS; GNC; Thermal Systems; Structure, Materials & Mechanisms; C&DH, Communications; TT&C; Software; Integration, Launch & Deployment; Ground Systems & Operations.
- State-of-the-Art = TRL 6 or above





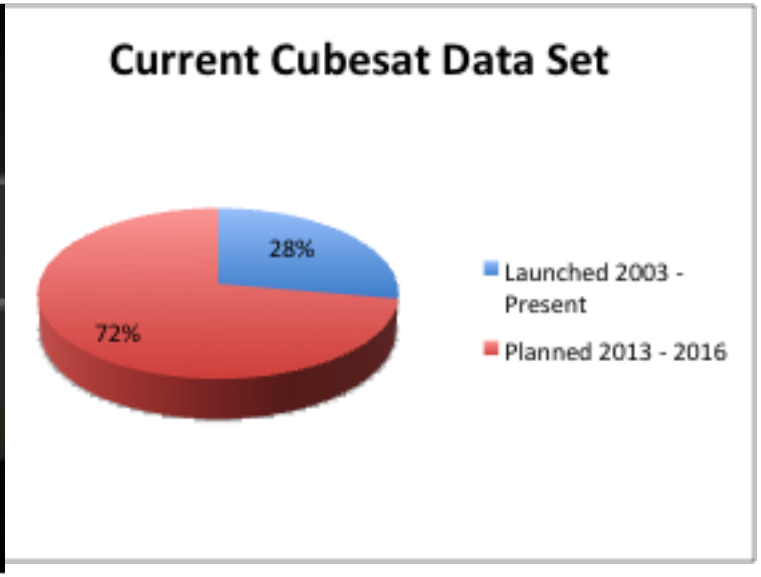
State of the Art Analysis

Summary

- Ongoing effort @ NASA ARC to draft a White Paper on the SoA of SS Technology.
- Work conducted on a best-effort basis with the goal to be as exhaustive as possible.
  - N.B. Due to finite resources, comprehensiveness cannot be guaranteed on the first pass.
- Results of assessment to be compiled within a living document.
  - Annual document revision to track changes in technology trends on a yearly basis.

Launch Portal

- To help Cubesat Rideshare community, STMD in collaboration with The Aerospace Corp and SMC's Space Test Program has established a launch portal website to bring developers and providers together
- What is it: a searchable web-based database to allow Cubesat developers to search for a list of candidate launch providers and vice-versa.
- What it *isn't*:
  - It is NOT an endorsement of launch providers or Cubesat missions
  - It is NOT an online marketplace
  - It is NOT a source of technical data
- URL - http://launchportal.arc.nasa.gov (expected "go live" August 31, 2013)



Launch Portal (cont'd)

- Benefits of use:
  - For a Cubesat developer, more likely to find a launch or a backup launch if first opportunity does not materialize
  - For a launch provider, more likely to fill up opportunity slots
  - Expectation is for more Cubesat missions in the next two years than in the last ten years. The community needs to embrace standard processes to avoid confusion and potential backlash.
  - Capability will evolve to include **ALL** rideshares (Cubesat, ESPA-class, duel manifested, etc.) in near future
- See a beta version demonstration (visit STMD/Aerospace Corporation booths)